# Restoration Categories and Descriptions

This appendix is divided into a description section and a design criteria section. There are five broad project categories (listed below): aquatic organism passage; instream, side-channel and floodplain; riparian vegetation; road and trail decommissioning; and restoration of seeps and springs. Each category is refined by type of project. The design criteria are organized by project type.

## PROJECT CATEGORIES

### Aquatic Organism Passage Projects

Aquatic organism improvement, barrier construction or improvement, and small dam removal. Aquatic organism passage restoration projects are as follows:

- Totally removing culverts, bridges, or other obstructions
- Replacing culverts or bridges with properly sized culverts and bridges
- Replacing a damaged culvert or bridge
- Resetting a culvert that was improperly installed or damaged
- Stabilizing and providing passage over headcuts
- Constructing, improving, or maintaining nonnative fish passage barriers
- Replacing, relocating, or constructing fish screens and irrigation diversions or modifying structure to accommodate fish passage where a barrier is created

#### *Irrigation Diversion Replacement/Relocation and Screen Installation/Replacement*

Routine operation, maintenance, and improvement of irrigation/acequia infrastructure to improve the condition and function of these systems and surrounding riparian vegetation, to promote water quality and ecosystem resilience.

Common infrastructure includes, but is not limited to:

- Irrigation ditch/acequia point of diversion from the water source (diversion dam or similar structure)
- the main irrigation ditch/acequia (*acequia madre*)
- lateral ditch/acequia that take water from the *acequia madre* to individual irrigated parcels
- drainages (*desagues*) that take excess irrigation water from the main ditch/acequia and return it to the water source

### Instream, Side-Channel, and Floodplain Projects

#### *Erosion Control Structures, Headcut and Grade Stabilization*

Reduce sedimentation and erosion, while increasing floodplain connectivity, infiltration, and increased riparian vegetation.

***Large Wood (LW), Boulder, and Gravel Placement (LW and Boulder Projects; Engineered Logjams; Porous Boulder Weirs and Vanes; Gravel Augmentation; Tree Removal for LW projects)***

Place large wood, boulders, and gravel in stream channels and adjacent floodplains in a manner that mimics natural conditions and locations.

***Reduction/Relocation of Recreation Impacts***

Remove or improve infrastructure associated with designated campgrounds, dispersed campsites, day-use sites, foot trails, and off-road vehicle roads and trails to improve riparian resources.

***Fencing, Stream Crossings, Pasture Improvements, and Off-Channel Wildlife/Livestock Watering***

Construct fences to protect aquatic restoration projects from other land uses and develop upland watering sources.

***Beaver Habitat Restoration***

Restore willow and other deciduous vegetation required to support beaver colonies through noncommercial conifer thinning; install in-channel structures to encourage beavers to build dams in incised channels and across floodplain surfaces.

***Streambank Restoration***

Restore streambanks that have been artificially altered to more natural conditions.

***Legacy Structure Removal***

Remove past structures, such as rock gabions and other in-channel and floodplain structures, that are inconsistent with current science and watershed processes.

***Channel Reconstruction/Relocation and Off- and Side-Channel Habitat Restoration***

Reconstruct or relocate altered stream channels in a manner that mimics natural gradient, bankfull width, and sinuosity; reconnect and restore relic side channels.

***Set Back or Remove Existing Berms, Dikes, and Levees***

Remove or set back berms, dikes, and levees to reconnect floodplains to inundation and stream channels with floodplains—Other restored ecological functions include overland flow during floods, dissipation of flood energy, increased water storage to augment low flows, sediment and debris deposition, growth of riparian vegetation, nutrient cycling, and development of side channels. Such projects will take place where floodplains have been disconnected from adjacent rivers through drainpipes and anthropogenic fill.

**Riparian Vegetation Treatments**

***Riparian Vegetation Planting***

Plant native riparian grasses, shrubs, and trees to restore native vegetation disturbed by aquatic restoration or past management actions.

***Riparian Vegetation Treatment (Controlled Burning)***

Conduct controlled burning to help restore plant species that would occur under natural fire regimes.

***Conifer and Nonnative Invasive Plant Removal When Encroaching in Riparian Areas, Meadows, and Wetlands***

Conduct noncommercial, mechanical, conifer thinning and nonnative vegetation removal in riparian areas to help restore riparian desired conditions for plant species composition and structure.

**Road and Trail Erosion Control and Decommissioning**
Decommission or relocate or both administratively used[1] and non-system roads and trails to hydrologically disconnect them from stream networks.

**Groundwater-Dependent Ecosystems: Restoration of Seeps and Springs**
Restore seeps and springs to their desired condition.

# Activity-Specific Design Criteria

## AQUATIC ORGANISM PASSAGE PROJECTS

Potential issue: Channel aggradation that leads to a fish passage barrier. This may also be addressed through Burned Area Emergency Response.

Potentially include fish barrier at low water crossings to exclude nonnative species, when needed.

Such projects will take place where fish passage has been partially or completely eliminated through road construction, stream degradation, small dam and weir creation, and irrigation diversions. Such equipment as excavators, bulldozers, dump trucks, and front-end loaders may be used to implement projects.

The design criteria below apply to different fish passage projects. Fish passage restoration has three components: stream simulation culvert and bridge projects, headcut and grade stabilization, and irrigation diversion replacement or relocation and screen installation or replacement.

**Stream Simulation Culvert and Bridge Projects**
Stream simulation culvert and bridge projects have three components: culvert criteria, bridge design, and crossing design. All stream crossing structures shall simulate stream channel conditions, in accordance with Stream Simulation: An Ecological Approach to Providing Passage for Aquatic Organisms at Road-Stream Crossings (USFS 2008a).

Culvert Criteria
Within the considerations of stream simulation, the structure shall, at a minimum, accommodate a bankfull-wide channel plus constructed banks to provide passage for all life stages of native fish species (for more information, reference chapter 6, page 35 of the Forest Service's Stream Simulation Guide [USFS 2008a]).

The following crossing-width guidance applies to specific ranges of entrenchment ratios, as defined by Rosgen (1996):

- Non-entrenched streams—If a stream is not fully entrenched (entrenchment ratio of greater than 1.4), the minimum culvert width shall be at least 1.3 times the bankfull channel width.
- Entrenched streams—If a stream is entrenched (entrenchment ratio of less than 1.4), the culvert width shall be greater than bankfull channel width, shall allow sufficient vertical clearance to allow ease of construction and maintenance, and shall provide adequate room for the construction of natural channel banks. Consideration shall be given to accommodate the flood-prone width, which measured at twice the maximum bankfull depth.

[1] Not open to the public

***Bridge Design***

- Bridges with vertical abutments—including concrete box culverts, which are constructed as bridges—shall have their stream channels designed according to culvert guidelines, including width.
- Structure material shall be concrete or metal. Concrete shall be sufficiently cured or dried before coming in contact with stream flow. The use of treated wood for bridge construction or replacement is not allowed under this project environmental assessment.
- Riprap shall not be placed in the bankfull width of the stream. It may be placed only below bankfull height when necessary to protect abutments and pilings; however, the amount and placement of riprap shall not constrict the bankfull flow.

***Crossing Design Criteria***

- Crossings shall be designed by an interdisciplinary design team, consisting of an experienced engineer, a fisheries biologist, and a hydrologist or geomorphologist.
- The USDA Forest Service aquatic organism passage design assistance team shall review crossing structures with widths that exceed 20 feet or with costs that exceed $100,000.
- At least one member of the design team shall be trained in a week-long aquatic organism passage course based on the USDA Forest Service's guide, Stream Simulation: An Ecological Approach to Providing Passage for Aquatic Organisms at Road-Stream Crossings (USFS 2008a).
- Bankfull width shall be based on the upper end of the distribution of bankfull width, as measured in the reference reach to account for channel variability and dynamics.
- Legacy pressure-treated and creosote-soaked wood components of crossings shall be removed when modifying stream crossings.
- Ensure fish passage, when appropriate, such as in a base flow channel. Cobble bedded with boulder cross-vane.

**Fish Passage Barriers**

Fish passage barriers are structures installed in stream channels to prevent the upstream migration of nonnative fish that are detrimental to native species. Structures are generally constructed of a concrete wall for upstream and downstream erosion protection or may involve augmentation of an existing natural geologic barrier.

***Design Criteria***

- An engineer with experience in fish passage design and construction shall design the fish passage barriers. The vertical drop shall be 5 feet at a minimum to a splash pad. Hydraulic modeling shall be conducted to ensure that, at a 100-year recurrence flood, the splash pad is not submerged, creating a pool that could allow fish to leap. The design shall take into account the leaping ability of species that the structure is designed to exclude.
- Temporary diversions for stormwater runoff shall be constructed as needed to direct flows around the work area. These diversions shall be designed, implemented, and maintained by the contractor, in accordance with best management practices (BMPs) to control erosion and sediment release. BMPs may include temporary berms, cofferdams, sediment basins, ditches, straw bales, straw mulch, and erosion control matting.

- Before the work begins, the contractor shall submit a construction dewatering plan for review and approval by the engineer and the United States Forest Service (USFS). The plan shall be a written procedure for implementing the construction dewatering requirements specified herein. It shall describe the layout, materials, and equipment and the operation and maintenance procedures proposed. The plan shall meet any criteria set forth in the Clean Water Act, Section 401 and 404, permits.

- If groundwater discharge points are observed during the field work, indicating that local groundwater levels are above the stream channel water surface elevations, then subsurface conditions at the site may lead to unstable excavations. If this is encountered, the contractor shall implement and maintain proper dewatering controls during construction.

- The contractor shall plan and execute work to control and minimize surface runoff from cuts, fills, and other disturbed areas.

- All construction equipment shall be decontaminated to prevent the spread of noxious weeds by cleaning it with high-pressure water before it is mobilized to or from the site. All wheels, tracks, undercarriages, fenders, blades, buckets and the exterior body shall be cleaned before it is allowed on or off the site. All construction equipment shall be inspected and approved by the project manager before it is brought onto the work area.

- Dewatering is anticipated for this project type. All dewatering flows collected from open sumps, trenches, or excavations shall be routed through a sediment retention structure before it is discharged to the receiving waterbody. All stormwater runoff from work areas also shall be routed through sediment retention structures before being discharged.

- BMPs shall be installed before any earth work that could release sediment to the receiving waterbody. BMPs shall remain in place until vegetation is established, as approved by the project manager. The USFS shall monitor the methods implemented by the contractor to ensure compliance with the BMPs.

- At the completion of the project, the contractor shall revegetate the site, using native, weed-free seed sources approved by the USFS.

**Small Dam Removal**

Small dam removal includes removal of small dams, channel-spanning weirs and abandoned diversion and other water retention structures. Projects will be implemented to reconnect stream corridors, floodplains, and estuaries, reestablish wetlands, improve aquatic organism passage, and restore more natural channel and flow conditions. Equipment such as excavators, bull dozers, end loaders, and similar equipment may be used to implement projects.

***Design Criteria***

- Structure dimensions—Small dams or other channel spanning structures that were constructed to impound water shall be less than 10 feet high and shall impound less than 15 acre-feet.

- Design review

    - Restoration review team—During the project design phase, the USFS shall ensure that this highly complex action is reviewed by the restoration review team of skilled restoration designers and practitioners.

- Information needs—The project sponsor shall provide the following information, plus any additional information requested:

    a. A longitudinal profile of the stream channel thalweg for 20 channel widths downstream of the structure and 20 channel widths upstream of the reservoir area (outside the influence of the structure) shall be used to determine the potential for channel degradation.

    b. A minimum of three cross-sections shall be used—one downstream of the structure, one through the reservoir area upstream of the structure, and one upstream of the reservoir exclusion area (outside the influence of the structure) to characterize the channel morphology and quantify the stored sediment.

    c. The contractor shall characterize the sediment to determine the proportion of coarse sediment (more than 2 millimeters [mm]) in the reservoir exclusion area.

    d. Reservoirs with a d35 of greater than 2 mm (65 percent of the sediment by weight exceeds 2 mm in diameter) may be removed without excavation of stored material, if the sediment contains no contaminants; reservoirs with a d35 of less than 2 mm (65 percent of the sediment by weight is less than 2 mm in diameter) shall require partial removal of the fine sediment to create a pilot channel, in conjunction with stabilization of the newly exposed streambanks with native vegetation. The new channel shall be designed based on the longitudinal profile and cross sections listed in items *a* and *b* above.

    e. If a project involves the removal of multiple barriers on one stream or in one watershed over the course of a work season, the contractor shall remove the most upstream barrier first, if possible.

**Low Water Crossings**

Three main types of crossing structures are designed to be submerged at some flows: unvented (simple) fords, vented fords, and low-water bridges.

Unvented or simple fords cross streams at or slightly above the elevation of the streambed without pipes (vents). Unvented fords fall into two categories—unimproved and improved.

Improved fords have a stable driving surface of rock, concrete, asphalt, concrete blocks, concrete planks, gabions, geocells, or a combination of materials. Sometimes a small channel or slot is included at the structure's low point to allow very low flows and aquatic animals to pass. The downstream roadway edge may be stabilized and defined with logs, riprap, gabions, or Jersey barriers.

Vented fords have a driving surface elevated some distance above the streambed, with culverts (vents) that enable low flows to pass beneath the roadbed. The vents can be one or more pipes, box culverts, or open-bottom arches. In streams carrying large amounts of debris, the driving surface over the vent may be removable, permitting debris to be cleared after a large flow event.

Low-water bridges are open-bottom structures with elevated decks and a total span of at least 20 feet.

Below is a summary of key engineering design elements for low-water crossings, adapted from Clarkin et al. (2006).

***Structure-Site Compatibility***

Select and design structures to maintain the function and bedload movement of the natural stream channel; conform to the natural channel shape and elevation, where possible

- Do not dam the natural channel or adjacent floodplains; keep the channel open.
- Do not cause significant aggradation in the channel upstream of the structure or degradation or downcutting downstream of the structure.
- Do not confine or narrow bankfull flows.
- Do not increase the natural stream channel velocity.
- Do accommodate major flood flows without significant drops in the water surface profile.
- Do align structures perpendicular to the stream channel.

***Fish and Aquatic Organism Passage***

Where needed and appropriate, select structures that will allow all aquatic species, particularly fish, to pass. For vented fords, open-bottom or embedded box culvert structures with a high vent-area ratio are often best. For simple fords, a roughened driving surface conforming to the grade and shape of the natural stream channel is best. A low-water bridge may be the best solution.

- Maintain natural streambed substrate material, roughness, slope, and form through all or part of the structure.
- Avoid accelerating the velocity of streamflow, particularly at normal and low flows.
- Build a structure, with either single or multiple spans, that is at least as wide as the bankfull width of the natural channel.
- Provide areas of diverse flow velocity and depth.
- Maintain swimmable low-flow depths.

***Roadway and Site Geometry***

Build a structure that fits the site, with a vertical and horizontal alignment that will be safe and will allow the design vehicle to pass over the crossing.

- Select a site with a relatively straight road alignment.
- Locate a crossing at a straight reach of the stream.
- Conform to the natural dip of the channel, as much as possible.
- Limit grades into the ford to 10 percent or less, if possible.
- Use a vertical curve dip through the ford that is sufficiently gentle to not catch the bumper or undercarriage of vehicles passing through the ford.
- Provide enough space at both ends of the crossing for backing up and turning around.

***Site Hydrology***

Ideally the contractor shall use either a flow-duration or flood-frequency (peak discharge) design approach to specifically size the low-water crossing structure. Nonetheless, when site hydrologic conditions are unknown or difficult to determine, low-water crossings make a good structure choice. They can easily be designed to be overtopped by a large volume of water and debris, and they are not sensitive to the exact flow quantity. Determining the hydrologic properties of a site shall be an interdisciplinary process, involving hydrologists and engineers.

- Determine the peak design flows (Q50 or Q100 events) to select the maximum size of the structure and identify maximum high-water level.
- Determine low-flow information (baseflow to Q2, or bankfull flow) to size the vents in a structure and estimate the frequency of probable delays.
- Quantify flows suitable for fish passage through structure or vents.
- Estimate traffic delay times using either flow-duration data or field knowledge of the site.

***Hydraulic Design***

Determine the site hydraulic factors needed for prudent structure design.

- Determine flow capacity through vents and over the structure, up to the high water elevation.
- Use computer models, Manning's equation, pipe capacity nomograms, or broad-crested weir formulas to determine flow through and over respective components of the ford.
- Determine stream velocities (through the structure) that will require riprap or other scour protection measures.
- Limit velocities to those suitable for needed fish passage.

***Scour, Bank Protection, and Channel Change Prevention***

Protect the channel, the structure, and its foundation against scour and erosion.

- Prevent accelerated stream flows that can damage structures, wash out the approaches, or deposit sediment into the watercourse.
- Prevent a "waterfall" and other scour-critical areas by keeping structures low to the channel and by avoiding channel constriction and mid-channel structures or obstructions.
- Install scour protection or energy dissipation measures, including rock riprap, concrete aprons and cutoff walls, gabion basket aprons, or plunge pools.
- Protect streambanks using biotechnical measures or such components as vegetation, erosion control or reinforcing mats, gabions, concrete blocks, and rock riprap.
- When riprap is used, size and place the rock to prevent rock movement resulting from the velocity and force of water.

***Structural Design of Driving Surface***

Design low-water crossings to support the design vehicle for the on-site soil conditions.

- Unless otherwise indicated, design all elevated structures (slabs, box culverts, or pipes) and bridges to support an 80,000-pound, HS-20-44 "legal" design load, in accordance with American Association of State Highway and Transportation Officials Standard Specifications for Highway Bridges requirements (AASHTO 2002).
- Provide at least one foot of compacted soil cover over culverts or a concrete slab (typically at least 6 to 8 inches thick) over box culverts, based on manufacturers' requirements or structural analysis.
- Construct the roadway driving surface with material durable enough or heavy enough to resist the shear stresses or lateral forces of the water flow.
- Protect the entire "wetted perimeter" of the ford,[2] plus freeboard, typically 2 to 4 feet of additional height.
- Remove soft or organic subgrade soil and replace it with select, structurally sound material in a layer thick enough to support the traffic without deformation.

***Traffic Control and Safety***

Consider all traffic safety issues to produce a safe crossing site.

- Ideally, locate low-water crossings at sites where the road is straight and sight distance is good.
- Build 6- by 10-inch wood or 15-inch-high concrete curbs to define the roadway and keep traffic on the structure.
- Place object markers along the road at each corner of the structure to define each entrance.
- Install warning signs to identify the approaching ford and warn drivers of flooding and possible traffic delays.
- Use marker posts that indicate the depth of flow.
- Consider making the ford extra wide for traffic safety and, wherever possible, use 4:1 or flatter ratio for slopes on embankments.
- If a site evaluation determines that a ford would be unsafe, choose a conventional structure, such as a culvert or standard bridge.

***Materials Selection***

Choose strong, durable, cost-effective materials for constructing low-water crossings. The driving surface may be made of local rock, aggregate confined in geocells, gabions, concrete planks, asphalt, masonry, or a massive concrete slab. Most vented box fords are made of structural steel-reinforced concrete, because of its strength and durability.

- Use local riprap, where appropriate, cost effective, and available in the necessary size (riprap is unsuitable if it is undersized and if the forces of water can move it).
- Where suitably large rock is not available for scour protection, use alternative materials such as gabions, grouted riprap, root wads with boulders, concrete blocks, or massive concrete.

[2] The area of the entire high flow

- In relatively low-velocity, low-energy areas, use such measures as vegetation or bioengineered streambank stabilization, erosion control mats, or turf reinforcing mats.
- Maintain materials quality control in the structure, in accordance with appropriate standard specifications.

***BMPs for Erosion Control and Water Quality Protection***

Use BMPs and incorporate erosion-control measures into the design, construction, and maintenance of low-water crossings to protect water quality.

- Incorporate construction dewatering into the project and avoid working in the water.
- Develop a project erosion-control plan, including appropriate physical, vegetation, or biotechnical measures, types of materials, and timing.
- Choose appropriate project BMPs and include them in project budgets, design, and project implementation; monitor them for implementation and effectiveness.
- Periodically inspect and maintain the structure to ensure that it is functioning properly.
- Disconnect the road from the stream crossing by diverting road surface water before it reaches the crossing; armor ditches and stabilize the roadway surface approaching the crossing.

**Irrigation Diversion Replacement/Relocation and Screen Installation/Replacement**

***Prescriptive Design Criteria***

- Diversion structures associated with points of diversion and future fish screens shall pass all life stages of threatened and endangered aquatic species that historically used the affected aquatic habitat.
- Water diversion intake and return points shall be designed, to the greatest degree possible, to prevent native fish in all life stages from swimming or being entrained in the diversion.
- All fish screens shall be sized to match the irrigator's state water right or estimated historical water use, whichever is less.
- The size of bypass structure shall be big enough to allow native and nonnative fish species to pass back into the stream.
- Abandoned ditches and other similar structures shall be plugged or backfilled, as appropriate, to prevent fish from swimming or being entrained in them.
- When making improvements to pressurized diversions, install a totalizing flow meter capable of measuring rate and duty of water use. For non-pressurized systems, install a staff gage or other measuring device capable of measuring instantaneous rate of water flow.
- For removing diversion structures constructed of local rock and dirt, the contractor shall dispose of the removed material in the following manner:
    - Material more than 60 percent silt or clay shall be disposed in uplands, outside of the active floodplain.

- Material with more than 40 percent gravel shall be deposited in the active floodplain but not in wetlands.
- Material with more than 50 percent gravel and less than 30 percent fines (silt or clay) may be deposited below the ordinary high water mark.

***Mitigation Design Criteria***

- The irrigation ditch or acequia shall be dewatered during the construction period so work will be accomplished "in the dry."
- Construction activities shall be timed to take advantage of low flow conditions, preferably conducted in the late summer to fall; construction during the spring, when stream flows are at their highest will not be permitted.
- No removal (grubbing) of woody riparian vegetation along the irrigation ditch or acequia or along forest roads (open or closed) is allowed, except what is necessary to allow replacement or re-construction. Vegetation that impinges on the work area may be trimmed or sheared to provide safe and adequate clearance of the work area for equipment operation and worker safety.
- All construction waste (concrete form material, leftover construction supplies, and litter and debris) shall be removed from the work area and disposed of in an approved manner off the National Forest.
- No construction shall occur within the floodplain or associated riparian area, except as defined in the description of the area of disturbance.
- No concrete washout or wasting of excess concrete is allowed on NFS lands. This material shall be removed from the National Forest and disposed of in an appropriate manner.
- All fueling and servicing of project heavy equipment shall be conducted in approved areas. Spill prevention, containment, and countermeasures plans are required if the volume of fuel exceeds 660 gallons in a single container or if total storage at a site exceeds 1,320 gallons.
- Before it arrives at the project area, equipment shall be cleaned of external oil, fluids, grease, dirt, mud, and plants and seeds. Equipment shall be inspected for leaks regularly. Any leaks shall be repaired and other repairs shall be made immediately and any soil contaminated due to leaks or other malfunctions shall be removed and disposed of in an appropriate manner.
- Pre-construction notification shall be given to the district ranger before construction begins.
- Once construction is complete, the disturbed area shall be returned to its original condition. This may include leveling, raking, native debris dispersal, and seeding for permanent groundcover.
- The proponent or contractor shall provide portable toilets for workers. Portable toilets shall be set back a minimum of 100 feet from the stream.
- Small, low ground pressure equipment and hand labor shall be used, where practicable.
- Surface water may be diverted to meet construction needs, but only if developed sources are unavailable or inadequate. If aquatic species are present or could be present, diversion shall not exceed 10 percent of the available flow and fish screens shall be installed, operated, and maintained.

- Soil, gravel, rock, and any material hauled to the project area shall come from sources determined to be weed free. A contracting officer's representative or designated inspector should approve sources as weed free.

- Following construction, the contractor shall monitor the area to detect invasive and noxious weeds. Identified weed infestations shall be treated in a manner consistent with applicable standards and policy.

- The contractor shall install all erosion control structures, such as silt fences, straw bales, or sandbag windrows, as needed before excavation occurs to prevent eroded soil from entering stream channel. The contractor shall maintain erosion control structures through the life of the construction project.

## INSTREAM, SIDE-CHANNEL, AND FLOODPLAIN PROJECTS

### Erosion Control Structures and Headcut and Grade Stabilization

Headcut and grade stabilization projects each have specific components. Headcuts often occur in meadow areas, typically on Rosgen C and E channel types. Headcuts develop and migrate during bankfull and larger floods, when the sinuous path of Rosgen E type streams may become unstable in erosive, alluvial sediments. This could cause avulsions, meander cutoffs, bank failures, and entrenched Rosgen G gully channels (Rosgen 1996).

Structure types include rock check dams, filter weirs, media lunas, straw bale filter dams, sheet piling dams, log and boulder cross vanes, Zuni bowls, log step downs, and rock plugs.

#### *Stabilize Headcuts*

- Armor headcuts with sufficiently sized and amounts of material to prevent continued upstream migration of the headcut; natural materials are preferable and include both rock and organic materials that are native to the area, if these materials are suitable in meeting project objectives; materials shall not contain gabion baskets, sheet pile, concrete, articulated concrete blocks, or cable anchors.

- Focus stabilization efforts in the plunge pool, the headcut, and a short distance of stream above the headcut.

- Minimize lateral migration of channel around headcut (flanking) by placing rocks and organic material at a lower elevation in the center of the channel cross section to direct flows to the middle of the channel.

- In streams with current or historical fish presence, provide fish passage using in-grade stabilization below or aquatic passage treatment category.

- In emergency situations, short-term headcut stabilization may occur without associated fish passage measures; however, fish passage shall be incorporated into the final headcut stabilization action and be completed during the first subsequent in-water work period.

- In streams without current or historical fish presence, it is not required to provide for fish passage.

#### *Grade Stabilization to Promote Fish Passage Associated with Headcut Stabilization*

- Provide fish passage over stabilized headcut through constructed riffles for pool/riffle streams or a series of log or rock weir structures for step/pool channels; if large wood and boulder placement will be used for headcut stabilization, refer to the *Large Wood, Boulder, and Gravel Placement* section.

- Construct weirs in a V shape, oriented with the apex upstream, and lower in the center to direct flows to the middle of channel.
- Key weirs into the streambed to minimize structure undermining due to scour, preferably at least 2.5 times their exposure height; also, key the weir into both banks; if feasible, greater than 8 feet.
- If several structures will be used in series, space the weirs at the appropriate distances to promote the passage of native fish in all life stage; incorporate state fish passage criteria, such as for jump height and pool depth, in the design of weir structures; recommended weir spacing shall be no closer than the net drop divided by the channel slope; for example, a 1-foot high weir in a stream with a 2 percent gradient will have a minimum spacing of 50 feet.
- Include fine material in the weir material mix to help seal the weir/channel bed, thereby preventing subsurface flow and ensuring fish passage following construction if natural flows are sufficient.
- If a project involves the removal of multiple barriers on one stream or in one watershed over the course of a work season, remove the most upstream barrier first, if possible.

**Large Wood (LW), Boulder, and Gravel Placement (LW and Boulder Projects; Engineered Logjams; Porous Boulder Weirs and Vanes, Gravel Augmentation; Tree Removal for LW Projects)**

***Large Wood and Boulder Projects***

- Large wood and boulders shall be placed in areas where they would naturally occur and in a manner that closely mimics natural accumulations for that particular stream type; for example, boulder placement may not be appropriate in low-gradient meadow streams.
- Structure types shall simulate disturbance events to the greatest degree possible and shall include logjams, debris flows, wind-throw, and tree breakage.
- The size or shape of structures shall not be limited, as long as such structures are within the range of natural variability of a given location and do not block passage of fish and other aquatic organisms.
- Projects can include grade control and bank stabilization structures, while size and configuration of such structures shall be commensurate with project site scale and hydraulic forces.
- The partial burial of large wood and boulders is permitted and may constitute the dominant means of placement. This applies to all stream systems but more so for larger stream systems, where use of adjacent riparian trees or channel features is not feasible or does not provide the full stability desired.
- Large wood includes whole conifer and hardwood trees, logs, and root wads. Large wood diameter and length shall account for bankfull width and stream discharge rates. When available, trees with root wads shall be a minimum of 1.5 times the bankfull channel width, while logs without root wads shall be a minimum of twice the bankfull width.
- Structures may partially or completely span stream channels or be positioned along stream banks.
- Stabilizing or key pieces of large wood shall be intact and hard, with little decay, and if possible have root wads (untrimmed) to provide functional refugia habitat for fish. Key pieces may be oriented such that the hydraulic forces on the large wood increase stability.
- Alternatives to anchoring large wood may be used in preferential order, as follows:

- Use adequately sized wood sufficient for stability.
- Orient wood in such a way that movement is limited.
- Place ballast (gravel, rock, or both) to increase the mass of the structure to resist movement.
- Use large boulders or posts, such as post-assisted log structures, as anchor points for the large wood.
- Using rebar, pin large wood to large rocks to increase its weight; for streams that are entrenched (Rosgen F, G, A, and potentially B) or for other streams with very low width-to-depth ratios (less than 12), an additional 60 percent ballast weight may be necessary due to greater flow depths and higher velocities.

***Engineered Logjams***

These are structures designed to redirect flow and change scour and deposition patterns. To the extent practical, they are patterned after stable natural logjams and can be either unanchored or anchored in place using rebar, rock, or piles. Engineered logjams create a low-velocity downstream zone that allows sediment to settle out. Scour holes develop next to the logjam; while providing valuable fish and wildlife habitat, they also redirect flow and can provide stability to a streambank or downstream gravel bar.

- Engineered logjams shall be patterned, to the greatest degree possible, after stable natural logjams.
- Stabilizing or key pieces of large wood used to provide streambank stability or redirect flows shall be intact and solid, with little decay; if possible, acquire large wood with untrimmed root wads to provide functional refugia habitat for fish.
- When available, trees with root wads attached shall be a minimum length of 1.5 times the bankfull channel width, while logs without root wads shall be a minimum of twice the bankfull width.
- The partial burial of large wood and boulders may constitute the dominant means of placement, and key boulders (footings) or large wood can be buried into the stream bank or channel.
- Angle and offset—The large wood portions of engineered logjam structures shall be oriented so the forces on the large wood increases stability. If a root wad is left exposed to the flow, the bole placed into the streambank shall be oriented downstream and parallel to the flow direction so the pressure on the root wad pushes the bole into the streambank and bed. Wood pieces oriented parallel to flow are more stable than pieces oriented at 45 or 90 degrees to the flow.
- If large wood anchoring is required, a variety of methods may be used; examples are buttressing the wood between riparian trees or using manila, sisal, or other biodegradable ropes for lashing connections. If hydraulic conditions warrant it, structural connections (rebar pinning or bolted connections) may be used. Rock may be used for ballast but is limited to that needed to anchor the large wood.

***Porous Boulder Weirs and Vanes***

- Full channel-spanning boulder weirs shall be installed only in highly uniform, incised, bedrock-dominated channels. The weirs shall be installed to enhance or provide fish habitat in stream reaches

where log placements are not practicable, due to channel conditions,[3] where damage to infrastructure on public or private lands is of concern, or where private landowners will not allow log placements due to concerns about damage to their streambanks or property.

- Boulder weirs shall be installed low in relation to channel dimensions so they are completely overtopped during channel-forming flow events (approximately a 1.5-year flow event); diagonally across the channel or in more traditional, upstream-pointing V or U configurations, with the apex (narrow end) oriented upstream; constructed to allow upstream and downstream passage of all native fish species and life stages that occur in the stream. Plunges shall be kept less than 6 inches in height.
- The use of gabions, cable, or other means to prevent the movement of individual boulders in a boulder weir is not allowed.
- Rock for boulder weirs shall be durable and of suitable quality to ensure long-term stability in the climate in which it is to be used. Rock sizing depends on the size of the stream, the maximum depth of flow, the planform[4], entrenchment, and ice and debris loading.
- The project designer or an inspector experienced in these structures shall be present during installation.
- Full-channel spanning boulder weir placement shall be coupled with measures to improve habitat complexity and protection of riparian areas, so as to provide long-term inputs of large wood.

**Reduction/Relocation of Recreation Impacts**

Reduction/relocation of recreation impacts is intended to close, better control, or relocate recreation infrastructure and use along streams and in riparian areas. This includes removing, improving, or relocating infrastructure associated with designated campgrounds, dispersed camp sites, day-use sites, foot trails, and off-road vehicle roads and trails in riparian areas. The primary purpose is to eliminate or reduce recreational impacts to restore riparian areas and vegetation, improve bank stability, and reduce sedimentation into adjacent streams. Such equipment as excavators, bulldozers, dump trucks, and front-end loaders may be used for projects.

- Remedial actions shall be designed to restore floodplain characteristics—elevation, width, gradient, length, and roughness—in a manner that closely mimics, to the extent possible, those that would naturally occur at that stream and valley type.
- To the extent possible, nonnative fill material shall be removed from the floodplain to an upland site.
- Overburden or fill comprised of native materials, which originated from the project area, can be used to reshape the floodplain, placed in small mounds on the floodplain, used to fill anthropogenic holes, buried on site, or disposed of into upland areas.
- For recreation relocation projects, such as campgrounds, horse corrals, off-road vehicle trails, current facilities shall be moved out of the riparian area or as far from the stream as possible.

[3] For example, where it is not feasible to place logs of sufficient length or in bedrock-dominated or deeply incised channel or artificially constrained reaches.

[4] The characteristics of a river as viewed from above (in an aerial photo, on a map, etc.), which are generally expressed in terms of pattern, sinuosity (channel length/valley length) and individual meander attributes such as amplitude, wavelength and radius of curvature

- The contractor shall consider de-compacting soils and vegetation planting once overburden material is removed.
- Barriers, such as boulders, fences, or gates, shall be placed outside of the bankfull width and across traffic routes to prevent off-road vehicle operators' access to and across streams.
- For work conducted on off-road vehicle roads and trails, relevant project design categories in Road and Trail Erosion Control and Decommissioning shall be followed.

**Fencing, Stream Crossings, Pasture Improvements, and Off-Channel Wildlife/Livestock Watering**
Projects will be implemented by the following:

- Constructing fences to exclude riparian grazing
- Providing controlled access for walkways that livestock use to cross streams and to pass through riparian areas
- Reducing livestock use in riparian areas and stream channels by providing upslope water facilities

Such projects promote a balanced approach to livestock use in riparian areas, reducing livestock impacts on riparian soils and vegetation, streambanks, channel substrates, and water quality. Such equipment as excavators, bulldozers, dump trucks, and front-end loaders may be used to implement projects.

***Fencing***

- Place fences to allow lateral movement of a stream and allow establishment of riparian plant species.
- Minimize vegetation removal when constructing fence lines, as appropriate to local site conditions.
- Where appropriate, construct fences at water gaps in a manner that allows passage of large wood and other debris.
- Use fencing materials and design that minimize environmental impacts and addresses migration of wildlife or other concerns, for example a pipe fence versus barbed wire.

***Stream Crossings***

- Minimize the number of livestock crossing in order to reduce resource impacts and balance needs of effective grazing management.
- Construct livestock crossings perpendicular to the direction of stream flow to prevent stream diversion.
- Locate crossings or water gaps where streambanks are naturally low; do not locate livestock crossings or water gaps in areas where compaction or other damage can occur to sensitive soils and vegetation (for example, wetlands) due to congregating livestock.
- To the extent possible, place crossings in areas that allow for the conservation of federal and state listed species and species of concern.
- Direct livestock to cross streams at existing access roads using fencing whenever possible, unless construction would result in less habitat disturbance.

- Design and construct livestock stream crossings or trails to avoid or minimize runoff of sediment and other pollutants to surface waters.
- Design and construct or improve livestock stream crossings to handle reasonably foreseeable flood risks, including associated bedload and debris.
- If necessary, stabilize the streambank and approach lanes with native vegetation, angular rock, or both to reduce chronic sedimentation.
- Do not allow livestock crossings to create barriers to the passage of adult and juvenile fish and amphibians.
- Design and construct stream crossings and water gaps to minimize the time livestock will spend in the crossing or riparian area.
- To the extent possible, when using pressure-treated lumber for fence posts, complete all cutting and drilling off-site so treated wood chips and debris do not enter water or flood-prone areas.
- Do not use fencing to create livestock handling facilities in riparian pastures.

***Off-Channel Livestock Watering Facilities***

- Water withdrawals shall not dewater habitats or cause low stream flow conditions that could affect aquatic species or habitat.
- Troughs or tanks fed from a stream, seep, spring, or river shall have an existing valid water right.
- Troughs shall be far enough from a surface water feature or be surrounded by a protective surface to prevent resource damage. Steep slopes shall be avoided, along with areas where compaction or damage could occur to sensitive soils, slopes, or vegetation due to congregating livestock.
- Each livestock water development shall have a float valve or similar device, a return flow system, a fenced overflow area, or similar means to minimize water withdrawal and potential runoff and erosion.
- Removal of vegetation around springs, seeps, or other wet areas shall be minimized.
- A protective fence or other obstruction such as woody debris shall be constructed around the spring development to prevent livestock damage.
- The contractor shall consider using umbrella drinkers, trick tanks, wells, or other means to minimize livestock impacts on wetlands and riparian areas.

**Beaver Habitat Restoration**

***In-Channel Structures***

- In-channel structures shall be porous and channel-spanning and shall be comprised of biodegradable vertical posts (beaver dam support structures) approximately 1.5 to 3 feet apart and at a height intended to act as the crest elevation of an active beaver dam. This restoration treatment may be varied to include post lines only, post lines with wicker weaves, starter dams, reinforced active and abandoned beaver dams (Pollock et al. 2012).

- Beaver dam support structures shall be placed in areas conducive to dam construction, as determined by stream gradient, historical beaver use, or both.
- In-channel structures shall be placed in areas with sufficient deciduous shrubs and trees to promote sustained beaver occupancy.

**Streambank Restoration**

***Design Criteria***

- Without changing the location of the bank toe, restore damaged streambanks to a natural slope and profile, such as from a reference reach, suitable to establish riparian vegetation; this may include sloping unconsolidated bank material to a stable angle of repose or using benches in consolidated, cohesive soils.
- Complete all soil reinforcement earth work and excavation during low flow conditions; when necessary, use soil layers or lifts strengthened with biodegradable fabrics and penetrable by plant roots.
- Include large wood to the extent it would naturally occur; if possible, large wood shall have untrimmed root wads to provide functional refugia habitat for fish; wood already in the stream or suspended over the stream may be repositioned to allow for greater interaction with the stream.
- Do not use rock for streambank restoration, except as ballast to stabilize large wood or when it is geomorphically appropriate for that site.
- Use a diverse assemblage of vegetation species appropriate to the project site; gather such vegetation as willow, sedge, and rush mats from local sources (for example, within the seed zone area), including abandoned floodplains and stream channels.
- Rehabilitate soil and vegetation source areas whenever possible.
- Do not apply surface fertilizer within 50 feet of any stream channel.
- Implement measures as necessary to prevent damage to vegetation and repaired banks.
- Conduct post-construction monitoring and treatment or removal of invasive plants until native plant species are well established.

**Legacy Structure Removal**

Remove structures that are detrimental to aquatic habitat or water quality. These structures may have been inappropriately installed, not maintained, and/or poorly designed. Examples of such structures include the following:

- Rock and gabion grade controls
- Log weirs
- Boulder steps
- Ineffective fish barriers

***Prescriptive Design Criteria***

- Ensure that structure materials that will remain on-site are appropriate
    - Materials typically found in the stream or floodplain at the site, such as large wood or boulders, may be reused at the site for habitat improvement.
    - Materials not typically found in the stream or floodplain at the site, such as concrete, rebar, and large boulders, shall be removed.
- If the structure being removed is keyed into the bank, fill in key holes with native materials to restore contours of stream bank and floodplain
    - Compact the fill material adequately to prevent the soil from washing out during over-bank flooding.
    - Do not mine material from the stream channel to fill in key holes.
- If the legacy structures were placed to provide grade control, evaluate the site for potential head-cutting and incision due to structure removal; if head-cutting and channel incision are likely to occur due to structure removal, additional measures, such as bioengineering techniques, shall be taken to reduce these impacts; as part of the design process, the costs and benefits of leaving the structure in place versus removing it shall be considered.
- If the structure is being removed because it has caused an over-widening of the channel, consider also implementing other restoration elements, such as reconstructing stream banks and implementing riparian planting, to decrease the width-to-depth ratio of the stream (as appropriate for the geomorphic setting).

***Mitigation Design Criteria***

- Where the removal of buried log structures may significantly disrupt riparian vegetation or the floodplain, consider using a saw to extract only the portion of log that is in the channel, leaving the buried sections in the streambank.
- Before arriving at a project site, the contracting officer's representative or Forest Service project facilitator shall inspect the equipment and sanitation supplies. The equipment shall be cleaned, sanitized, and inspected between sites:
    - Equipment shall be free of external oil, grease, dirt, mud, plants, and seeds; it shall be pressure washed or steam cleaned before the start of the project.
    - Equipment shall be sanitized, for example with a bleach-water spray solution, and free of such aquatic species as rock snot and whirling disease-causing organisms, if it will be used in or near water.
    - Personnel entering a waterbody shall sanitize their wading equipment, for example with a bleach-water spray solution.
- Leaking equipment shall not be used in or near surface water.
- The contractor shall inspect all project equipment daily for external synthetic and petroleum products. A written log of inspections and maintenance shall be completed and maintained throughout the

project period. The contracting officer's representative or Forest Service project facilitator shall periodically check the equipment.

- The time in which heavy equipment is in stream channels, riparian areas, and wetlands shall be minimized and earth work shall be completed as quickly as possible.
- To protect resources and ensure appropriate working conditions, work shall occur within Forest Service-specified times. Work shall not occur—or, if begun, shall cease—during wet conditions; scheduled work shall not be done during periods of predictable flooding, including dam releases. All in-channel work shall be conducted during dry or low flow periods. The risk of flooding shall be considered, and the weather forecast shall be monitored.
- To the extent feasible, heavy equipment work shall take place from the top of the bank, unless work instream would result in less damage to the aquatic ecosystem. Equipment shall never be parked within the stream channel or wetland.
- On project completion, all disturbed areas shall be rehabilitated in a manner that results in similar or better than pre-work conditions. This shall be accomplished by removing project-related waste, spreading stockpiled materials, such as soil and trees, seeding, or planting with local, native varieties.
- To minimize erosion and promote vegetation as groundcover, short-term stabilization measures shall be used, such as weed-free certified straw and jute matting. Measures shall be maintained until vegetation is effectively established or soils are stable or both. On completing earth work and planting, stabilization measures shall be put in place.

**Channel Reconstruction/Relocation and Off-Channel and Side-Channel Habitat Restoration**

There are two categories of effort that need to be planned and implemented together: earth work to change the flow of water and riparian revegetation to stabilize the soil and improve water quality.

***Channel Work***

- Restoration, reconstruction, and relocation—Adjust or create a water course by mimicking the morphology of site-appropriate natural channels, floodplains, and wetlands. Important elements of design are gradient, entrenchment, bankfull width, sinuosity, and substrate. For wetlands, restoration may include plugging gullies with fill material.
- Off-channel and side-channel habitat restoration—Reactivate and restore relic (natural) side channels by removing manufactured fill and plugs, thereby preventing their connection with the main channel. New off-channel habitat may be constructed by, for example, digging ponds, where appropriate and necessary.
- Floodplain and wetland restoration—Set back or remove existing berms, dikes, and levees to reconnect stream channels with floodplains and wetlands with water sources.

***Revegetation***

- Plant native, locally sourced (where possible) riparian grasses, shrubs, and trees to restore vegetation disturbed by restoration or past management actions.

***Prescriptive Design Criteria***

*Channel work*

Data requirements and analysis for restoration are evidence of historical channel location, such as land surveys, photographs, topographic maps, remote sensing data, and personal observation.

- Design and construct geomorphically appropriate stream channels, floodplains, and wetlands; consider the valley type and watershed setting, for example, channel bed elements shall fit within the geomorphic context of the stream system; constructed riffles shall be preferentially used in pool-riffle stream types, while roughened channels and boulder step structures shall be preferentially used in step-pool and cascade stream types.
- Select materials for instream structures that will mimic natural (reference) stream system materials, for example large wood, rock, and gravel.
- For floodplain restoration or construction, loosen compacted soils once overburden material is removed; where appropriate on the floodplain, use overburden or fill comprised of native materials from the project area.
- For cobble bed streams, ensure sand and gravels are properly mixed into the newly constructed channel bed so as to prevent water from going subsurface; inspect the new channel when re-watering to ensure flows do not go subsurface; if flows are lost, wash fine sediment into the substrate to seal interstitial spaces; if water loss continues, turn off re-watering and remix substrate using an excavator.
- For off-channel and side-channel improvements, excavate naturally accumulated sediment within historical channels; excavation depth typically shall not exceed the maximum thalweg depth in the main channel.
- In some cases, construct new off-channel and side-channel habitat where it is otherwise limited in the watershed and where it is geomorphically appropriate for the site.
- Where a newly constructed channel will meet an existing channel, ensure head-cutting will not occur through the use of grade controls.
- Consider using bio-engineering or sinuosity as channel gradient for lateral position and control.
- Monitored the project in the short term for erosion, soil moisture for plantings, and weed infestations and in the long term for meeting objectives and plant survival (80 percent survival of planted vegetation is considered successful).

*Revegetation*

- All plants and seeds shall be native to the area and, where possible, locally sourced. Where on-site vegetation is not available to use, a native, certified weed-free seed mix and site-appropriate rooted stock or sprigs of native vegetation, such as willow cuttings, may be used. Where feasible, revegetation may be accomplished by storing sod or clumps of plants from adjacent areas before earth work and then replaced, using heavy equipment. Seed mixes and plant species shall be approved by a qualified biologist.
- The contractor shall retain site-appropriate trees and shrubs as feasible for reuse in reclamation and restoration activities, shall ensure appropriate storage to retain vitality, and shall remove nonnative and invasive species.

- The contractor shall use and develop soil and plant substrate suitable for restoring desired vegetation types.
- Planting shall be climate appropriate; that is, planting shall not take place under drought conditions without also providing for water.

***Mitigation Design Criteria***

*Channel work and revegetation*

- The project designer, or qualified expert, shall be present during key phases of implementation. The Forest Service project facilitator shall be involved at key milestones and decision points.
- Before construction and site preparation begin, a biologist or watershed specialist shall clearly mark riparian vegetation and other sensitive areas in which ground disturbance needs to be minimized or avoided. Wetlands need to be delineated on the ground by a specialist qualified to identify wetland characteristics.
- Heavy equipment shall be task appropriate and operated in a manner that minimizes adverse effects on the environment; for example, minimally sized, low pressure tires, minimal hard turn paths for tracked vehicles, temporary mats or plates shall be used in wet areas or on sensitive soils.
- To the extent feasible, heavy equipment shall be operated from the top of the bank, unless work in-stream would result in less damage to the aquatic ecosystem. Equipment shall never be parked within the stream channel or wetland.
- The time in which heavy equipment is in stream channels, riparian areas, and wetlands shall be minimized and earth work shall be completed as quickly as possible.
- To protect resources and ensure appropriate working conditions, work shall occur within Forest Service-specified times. Work shall not occur and, if already begun, shall cease during wet conditions; work shall not be scheduled during periods of predictable flooding, including dam releases. All in-channel work shall be conducted during dry or low flow periods. The risk of flooding shall be considered and the weather forecast shall be monitored.
- All channel and floodplain work shall occur during specified times or prescribed by weather and flood flows.
- For fish and aquatic organism salvage operations, native fish, amphibians, and mussels (referred to as fish salvage) shall be relocated from the area in a manner that results in minimal injury or disturbance. A fisheries biologist shall be on-site during dewatering and during all salvage operations.
- During construction, the potential for erosion shall be minimized; stream flow shall be diverted into a temporary channel (or pipe), thereby ensuring the volume of potential floods are planned for. Diversion structures shall be non-erodible, such as sandbags, water bladders, concrete barriers, or the channel shall be lined with geotextile or plastic sheeting. Dirt cofferdams are not acceptable diversion structures. Water shall be released slowly into the new channel.
- The work channel shall be pumped dry, and all pumps shall have fish screens. Block nets shall be installed at the upstream end of the diversion to protect aquatic organisms from project activities.

- When working next to surface water or stream channels, sediment buffers, such as silt fencing, waddles, or excelsior mats, shall be used. Imported barrier material shall be removed at the completion of work.
- Surface water may be drafted to meet construction needs, but only if developed sources are unavailable or inadequate. If using developed sources, the water shall be free of contaminants that could violate water quality standards. If aquatic species are present or may be present, drafted volume shall not exceed 10 percent of the available flow. Fish screens shall be installed and maintained on pumps.
- Clearing and grubbing shall be minimized when preparing staging or stockpiling areas. Any large wood, topsoil, and native channel material displaced by construction shall be stockpiled for use during restoration; these materials may be staged within the 100-year floodplain, but not below the active channel (below bankfull elevation) and replaced as soon as possible.
- Nonnative fill material shall be removed from the channel and floodplain and hauled to an upland site.
- Existing roadways shall be used whenever possible. Construction of new permanent roads is not permitted.
- The number and length of temporary stream and wetland crossings needed for construction shall be minimized. Such crossings shall be at right angles to the feature, at the narrowest point possible, and sensitive areas shall be avoided to the greatest extent possible. Stream crossings shall not increase the risk of stream diversion, erosion, and sedimentation; for example, the approaches to the channel shall be at a gentle angle. Channel substrate at the crossing may need armoring. After project completion, temporary crossings shall be restored by the end of the applicable work period.
- Before arriving at a project site, the contracting officers representative or Forest Service project facilitator shall inspect the equipment and sanitation supplies. The equipment shall be cleaned, sanitized, and inspected between sites, as follows:
    - Equipment shall be free of external oil, grease, dirt, mud, plants and seeds. Equipment shall be pressure washed or steam cleaned, or both, before the start of the project.
    - Equipment being used in or near water shall be sanitized with, for example, a bleach-water spray solution and shall be free of aquatic species, such as rock snot and organisms that cause whirling disease.
    - Personnel entering a water body shall sanitize their wading equipment , for example with a bleach-water spray solution.
- Leaking equipment shall not be used in or near surface water. The contractor shall inspect the project equipment daily for external synthetic and petroleum products. A written log of inspections and maintenance shall be completed and maintained throughout the project period. The contracting officer's representative or Forest Service project facilitator shall check the equipment periodically.
- Petroleum products (and other potential water quality contaminants) shall be staged well away from surface water, in a designated (e.g., flagged) area outside of the 100-year floodplain and riparian

management zones. All vehicles and heavy machinery shall be fueled and serviced at the designated staging area.

- Heavy equipment shall never be parked within the stream channel or other sensitive areas, such as wetlands.
- A spill prevention, control, and containment plan shall be approved by the contracting officer's Representative and kept on-site. A containment and cleanup kit, including booms and absorbent pads, shall also be kept on-site. Petroleum products shall be stored in impervious containment structures having a capacity equal to twice the petroleum volume.
- Soil, gravel, rock, and any material hauled to the project area shall come from sources determined to be weed free. The contracting officer's representative or designated inspector shall approve the sources as weed free.
- To minimize erosion and promote vegetation as groundcover, short-term stabilization measures, such as weed-free certified straw and jute matting, shall be used. Measures shall be maintained until vegetation is effectively established or soils are stable, or both. On completing earth work and planting, stabilization measures shall be installed.
- Following project implementation, planted areas shall be monitored to help ensure survival and to detect invasive and noxious weeds. Identified weed infestations shall be treated to prevent spread.
- Surface fertilizer shall not be applied within 300 feet of any stream channel, and other fertilizers shall not be used along streams impaired for nutrients.

**Set-Back or Removal of Berms, Dikes, and Levees**

***Floodplains***

- Design actions to restore floodplain characteristics—elevation, width, gradient, length, and roughness—in a manner that closely mimics, to the extent possible, those that would naturally occur at that stream and valley type.
- Remove drainpipes, fences, and other capital projects to the extent possible.
- To the extent possible, move nonnative fill material from the floodplain to an upland site.
- Where it is not possible to remove or set back all portions of dikes and berms, or in areas where existing berms, dikes, and levees support abundant riparian vegetation, create openings with breaches. Breaches shall be equal to, or greater than, the active channel width to reduce the potential for channel avulsion during floods. In addition to other breaches, the berm, dike, or levee shall always be breached at the downstream end of the project, at the lowest elevation of the floodplain, or both to ensure the flows will naturally recede into the main channel, thus minimizing fish entrapment.
- Do not allow dike and levee setback elevations to exceed the elevation of removed structures.
- When necessary, loosen compacted soils once overburden material is removed. Overburden or fill comprised of native materials from the project area may be used within the floodplain to create set-back dikes and fill human-caused holes, provided that floodplain function is not impeded.

## RIPARIAN VEGETATION TREATMENTS

### Riparian Vegetation Planting

#### *Beaver Habitat Restoration*

- Drainages historically occupied by beavers, but that may be currently unsuitable for relocation, may require management for improvement and recovery. Restoration may include planting native riparian hardwood species, such as willow, cottonwood, aspen, red osier dogwood, and alder, and building exclosures, such as temporary fences, to protect and enhance existing or planted riparian hardwoods until they are established.

- Grazing plans shall be maintained or developed to ensure the success of beaver habitat restoration objectives.

#### *Juniper Tree Removal*

- Remove juniper to natural stocking levels where Forest Service personnel determine that they are expanding into neighboring plant communities, to the detriment of other native riparian vegetation, soils, or streamflow.

- Do not cut old-growth juniper, which typically has several of the following features: sparse limbs, dead limb or spiked tops, deeply furrowed and fibrous bark, branches covered with bright green arboreal lichens, noticeable decay of cambium layer at base of tree, and limited terminal leader growth in upper branches (Miller et al. 2005).

- Retain approximately 10 percent of the juniper treatment area in uncut patches.

- Felled trees may be left in place, lower limbs may be cut and scattered, or all or part of the trees may be used for streambank or wetland restoration. For example, felled trees may be manipulated to protect riparian or wetland shrubs from grazing by livestock or wildlife or used to restore ecological function in floodplain, riparian, and wetland habitats.

- Where appropriate, cut juniper may be placed into stream channels and floodplains to provide aquatic benefits. Juniper can be felled or placed into the stream to promote channel aggradation, as long as such actions do not obstruct fish movement and use of spawning gravels or increase width-to-depth ratios.

- On steep slopes, south-facing slopes, or both, where ground vegetation is sparse, leave felled juniper in sufficient quantities to promote reestablishment of vegetation and prevent erosion.

- If seeding is a part of the action, consider whether seeding would be most appropriate before or after juniper treatment.

- When using feller-buncher and slash-buster equipment, operate equipment in a manner that minimizes soil compaction and disturbance to soils and native vegetation to the extent possible. Equipment exclusion areas (buffer areas along stream channels) shall be as wide as the feller-buncher or slash-buster arm.

#### *Riparian Vegetation Planting*

- Experienced silviculturists, botanists, ecologists, or associated technicians shall be involved in designing vegetation treatments.

- All riparian seeding and plantings shall follow Forest Service direction described in Forest Service Manual 2000, National Forest Resource Management Chapter 2070 – Vegetation Ecology (USFS 2008b) and Forest Service Manual 2472 – Reforestation (USFS 2014).
- Species to be planted shall be of the same species that naturally occur in the project area. Native seed, plant sources, or both shall be used, following guidance from geneticists and established seed zones and plant movement guidelines for the species being revegetated.
- The planting plan shall ensure sufficient survival to meet project objectives.
- Tree and shrub species, willow cuttings, as well as sedge and rush mats to be used as transplant material shall come from outside the bankfull width, typically in terraces (abandoned floodplains), or where such plants are abundant.
- Sedge and rush mats shall be sized to prevent their movement during high-flow events.
- Plantings shall be concentrated above the bankfull elevation.
- Removal of native and nonnative vegetation that will compete with plantings is permitted. For instance, native grasses next to deciduous tree plantings can be removed.
- Exclosure fencing to prevent utilization of plantings by deer, elk, and livestock is permitted.

**Riparian Vegetation Treatment (Controlled Burning)**

***Low and Moderate Severity Burns***

- Experienced fuels specialists, silviculturists, fisheries biologists, and hydrologists shall be involved in designing prescribed burn treatments.
- Prescriptions shall be focused on restoring the plant species composition and structure that would occur under natural fire regimes.
- Burn plans are required for each action and shall include the following:
    - A description of existing and desired future fire classifications and existing and target stand structure and species composition, including the basis for target conditions
    - Other ecological objectives, type, severity, area, and timing of proposed burn
    - Measures to prevent destruction of vegetation that provides shade and other ecological functions important to habitat
- Low-severity burns shall be used, except where the objective is to restore deciduous trees, as described below, with a goal of creating a mosaic pattern of burned and unburned landscape. Low-severity burns, as defined in the National Fire Plan (2002), are characterized by the following:
    - Low soil heating or light ground char occurs where litter is scorched, charred, or consumed, but the duff is left largely intact
    - Woody debris accumulation is partially consumed or charred
    - Mineral soil is not changed

  - Minimal numbers of trees, typically pole-sized and saplings, would be killed

- Moderate severity burns are permitted only where needed to invigorate decadent aspen stands, willows, and other native deciduous species. They may be targeted in no more than 20 percent of the area in the riparian habitat conservation area or riparian reserves, per 6th-field hydrologic unit code watershed per year. Such burns shall be contained within the observable historical boundaries of the aspen stand, willow site, other deciduous species, and associated meadows; additional exclusion areas outside historical boundaries may be added to create controllable burn boundaries. Moderate severity, as defined in the National Fire Plan (2002), is characterized by the following:

  - Moderate soil heating or moderate ground char occurs where the litter on forest sites is consumed and the duff is deeply charred or consumed, but the underlying mineral soil surface is not visibly altered

  - Light colored ash is present

  - Woody debris is mostly consumed, except for logs, which are deeply charred

- Fire lines shall be limited to 5 feet in width, constructed with erosion control structures, such as water bars, and restored to pre-project conditions before the winter following the controlled fire. To the extent possible, vegetation providing stream shade or other ecological functions that are important to streams shall not be removed.

- Ignition can occur anywhere in the riparian areas, as long as project design criteria are met.

- Water withdrawals from fish-bearing streams shall be avoided whenever possible. Water drafting shall take no more than 10 percent of the stream flow and shall not dewater the channel to the point of isolating fish.

***Noncommercial Thinning Associated with Moderate Severity Burns***[5]

- Noncommercial tree thinning and slash removal is allowed only as required to adjust fuel loads to implement a moderate severity burn to promote growth of deciduous trees and shrubs, such as aspen, cottonwood, willow, other deciduous species, and associated meadows.

- To protect legacy trees, thinning from below is allowed. If conifers are even-aged pole, sapling, or mid-seral, with no legacy trees, existing trees shall be thinned to the degree necessary to promote a moderate severity burn.

- No slash burning is allowed within 30 feet of any stream. To the extent possible, creating hydrophobic soils when burning slash shall be avoided. Slash piles shall be far enough from the stream channel so that any sediment resulting from this action will be unlikely to reach any stream.

- Only hand equipment, such as chainsaws, axes, and Pulaskis, may be used for felling.

- Where livestock grazing, wildlife grazing, or both could be a threat to restoration of aspen, cottonwood, willow, alder, and other deciduous vegetation and where an immediate moderate severity burn would consume large amounts of felled trees, the contractor shall consider delaying the

[5] Because thinning and moderate-severity burns are coupled, thinning was not separated into its own project design criteria section.

burn and leaving felled trees in place to create grazing barriers. This would be done to help ensure plant growth.

- All projects in this category shall be accompanied by livestock grazing practices that promote the attainment of moderate severity burn objectives.

**Conifer and Nonnative Invasive Plant Removal When Encroaching in Riparian, Meadow, and Wetland Areas**

Conifers shall be removed in riparian areas and adjoining uplands to help restore plant species composition and structure that would occur under natural fire regimes. Removal shall occur in those areas where conifer tree species have encroached into riparian areas as a result of fire exclusion, thereby replacing more desired riparian plant species, such as willow, cottonwood, aspen, alder, sedge, and rush. This action will help restore composition and structure of desired riparian species, thereby improving ground cover and water infiltration into soils. Equipment may include chainsaws, pruning shears, winch machinery, feller-bunchers, and slash-busters. The following measures shall apply:

- Remove conifer species to natural stocking levels where the Forest Service determines that conifers are expanding into neighboring plant communities, to the detriment of other native riparian vegetation, soils, or streamflow.

- Do not cut old-growth conifers, which typically have several of the following features: sparse limbs, dead limbed or spiked tops, deeply furrowed and fibrous bark, branches covered with bright-green arboreal lichens, noticeable decay of cambium layer at base of tree, and limited terminal leader growth in upper branches (Miller et al. 2005).

- Felled trees may be left in place, lower limbs may be cut and scattered, or all or part of the trees may be used for streambank or wetland restoration; for example, they may be manipulated as necessary to protect riparian or wetland shrubs from livestock or wildlife grazing, or ecological function may be restored in floodplain, riparian, and wetland habitats.

- Where appropriate, cut conifers may be placed into stream channels and floodplains to provide aquatic benefits. Conifer trees can be felled or placed into the stream to promote channel aggradation, as long as such actions do not obstruct fish movement, increase width-to-depth ratios, and do not pose a risk to nearby infrastructure during high-flow events.

- If seeding is a part of the action, consider whether seeding would be most appropriate before or after conifer removal.

- When using feller-buncher and slash-buster equipment, operate it in a manner that minimizes soil compaction and disturbance to soils and native vegetation to the extent possible; equipment exclusion areas (buffer areas along stream channels) shall be as wide as the feller-buncher or slash-buster arm.

- Slash may be piled and burned, as needed, to meet fuel reduction objectives, provided adequate buffer distance is provided.

- Slash and tree boles may be removed for fuelwood, provided the material is decked away from riparian area or wetlands.

**ROAD AND TRAIL EROSION CONTROL AND DECOMMISSIONING**

These activities would apply to the following:

- Non-system roads and trails (motorized and nonmotorized)
- National Forest system nonmotorized trails
- National Forest system roads that are not on the Motor Vehicle Use Map *and* were found to be unneeded by the Subpart A, travel management plan
- National Forest System motorized trails that are not on the Motor Vehicle Use Map

**Erosion Control**

Erosion control measures may include relocating a system road or trail to a hydrologically preferred location, such as a ridgetop, while also decommissioning the route in the undesired location, such as up the stream channel. Other measures include installing structures or otherwise altering the route in order to control the flow of water, thereby removing it from the travel way as soon as possible. Erosion control structures may include rolling dips, water bars, out-sloping, drainage pipes, lead-off ditches, boardwalks, and corduroy.

**Decommissioning**

Road and trail decommissioning is defined as activities that result in the stabilization and restoration of travel routes to a more natural state (36 CFR 212.1, FSM 7705), where restoration includes disconnecting the route from the hydrologic network. The Forest Service Manual (7712.11) identifies five levels of treatments for decommissioning that can achieve the intent of the definition, as follows:

- Blocking the entrance
- Revegetating and water barring
- Removing fills and culverts
- Establishing drainage-ways and removing unstable road shoulders
- Implementing full obliteration recontouring and restoring natural slopes

These five treatment levels provide a range of options to stabilize and restore hillslopes. A field analysis of each travel route shall inform which treatment level is best. The route and hillslope response to any treatment is strongly influenced by such local factors as climate, geology, topography, soil, and road design and construction.

***Prescriptive design criteria***

- Roads and trails may be decommissioned by a variety of treatment levels (see Forest Service Manual 7712.11). For restoration of hillslope hydrology on a cut-and-fill route, a full recontour treatment is recommended. Consider the cost-benefits of decompaction versus maintaining the vegetation at sites with limited potential for revegetation.
- Decommissioned roads shall not be able to convey motorized traffic. Decommissioned roads shall have no berms, ditches, or water traps of any kind nor any drainage structures or features that require maintenance.
- Where roads cross streams or draws, culverts or drainage structures shall be removed, reestablishing the natural stream grade. A natural channel width shall be restored through total removal of all road fill. Structures in the stream bed that mimic a natural stream channel, such as steps, may be constructed.

- Erosional features that convey water down the roadbed shall be treated; blocking the entrance to a road with severe gully erosion is not an appropriate level of treatment; drainage needs to be addressed to ensure the gullies no longer carry water.
- Appropriate native riparian species shall be planted to stabilize soil and improve water quality; if possible, source plants from site-salvaged or local sources.
- All seeps and springs that intersect the road prism shall be restored to follow natural drainage patterns.
- Where on-site vegetation is not available, a native, certified weed-free seed mix and site-appropriate rooted stock or sprigs, such as willow cuttings, of native vegetation may be used. Where feasible, revegetation may be accomplished by storing sod or clumps of plants from the route or adjacent areas before earth work begins and then replaced with heavy equipment. Seed mixes and plant species shall be approved by a qualified biologist.
- Planting shall be climate appropriate; that is, do not plant in drought conditions without also providing for water.
- Newly treated routes may be mulched with slash from site-cleared trees and brush to achieve approximately 40 to 60 percent coverage.
- Locally sourced materials, such as rock, slash, and plants, are preferred to imported materials.
- Before planting, soil shall be decompacted via scarifying or cratering.

***Mitigation design criteria***

- Minimize the time in which heavy equipment is in stream channels, riparian areas, and wetlands; complete earth work as quickly as possible.
- To protect resources and ensure appropriate working conditions, work within Forest Service-specified periods; work shall not occur, and, if begun, shall cease, during wet conditions; work shall be scheduled to avoid periods of predictable flooding, including dam releases. All in-channel work shall be conducted during dry or low flow periods.
- When working next to surface water or stream channels, sediment buffers, such as silt fencing, waddles, and excelsior mats, shall be used. Imported barrier material shall be removed at the completion of work.
- To minimize erosion and promote vegetation as groundcover, short-term stabilization measures, such as weed-free certified straw and jute matting, shall be used. Measures shall be maintained until vegetation is effectively established or soils are stable or both. On completing earth work and planting, stabilization measures shall be installed.
- Protective measures shall be used to prevent ripped or excavated soil or rock from entering surface waters.
- When there is excess fill material, it shall be placed in stable areas, such as flat landings, outside of stream channels and floodplains.
- Heavy equipment shall be appropriate for the tasks required and shall be approved by the Forest Service before it is implemented.

- Before arriving at a project site, the contracting officer's representative or the Forest Service project facilitator shall inspect the equipment and sanitation supplies. The equipment shall be cleaned, sanitized, and inspected between sites, as follows:
    - Equipment shall be free of external oil, grease, dirt, mud, plants and seeds; it shall be pressure washed or steam cleaned, or both, before the start of the project.
    - When work is to be conducted in or near water, equipment shall be sanitized, for example using a bleach-water spray solution, and free of aquatic species, such as rock snot and organisms that cause whirling disease.
    - Personnel entering a waterbody shall sanitize their wading equipment, for example with a bleach-water spray solution.
- Leaking equipment shall not be used in or near surface water. The contractor shall inspect the project equipment daily for external synthetic and petroleum products. A written log of inspections and maintenance shall be completed and maintained throughout the project period. The contracting officer's representative or Forest Service project facilitator shall periodically check the equipment.
- Petroleum products shall be staged well away from surface water, in a designated (e.g., flagged) area outside of the 100-year floodplain and riparian management zones. All vehicles or heavy machinery shall be fueled and serviced at the designated staging area.
- Heavy equipment shall never be parked within the stream channel or other sensitive areas, such as wetlands.
- A spill prevention, control, and containment plan shall be approved by the contracting officer's representative and kept on-site. A containment and cleanup kit, including booms and absorbent pads, shall also be kept on-site. Petroleum products shall be stored in impervious containment structures with a capacity equal to twice the petroleum volume.
- Following project implementation, planted areas shall be monitored to help ensure survival and to detect invasive and noxious weeds. Identified weed infestations shall be treated to prevent spread.
- Surface fertilizer shall not be applied within 300 feet of any stream channel, and other fertilizers shall not be used along streams impaired for nutrients.
- Surface water may be drafted to meet construction needs, but only if developed sources are unavailable or inadequate. If developed sources are used, the water shall be free of contaminants that could violate water quality standards. If aquatic species are present or may be present, drafted volume shall not exceed 10 percent of the available flow. Fish screens shall be installed and maintained on pumps.
- For fish and aquatic organism salvage operations, fish, amphibians, and mussels (referred to as fish salvage) shall be removed or driven from the area in a manner that results in minimal injury or disturbance. A fisheries biologist shall be on-site during dewatering and during all salvage operations.
- Before site preparation and construction, a biologist or watershed specialist shall clearly communicate via, for example flagging or a map, riparian vegetation, wetlands, and other sensitive areas in which ground disturbance needs to be minimized or avoided.

- Streams and wetlands shall be crossed at their narrowest point and crossings shall be limited to a single location. Stream channels shall be crossed perpendicular to their banks.
- Construction shall be scheduled in wetlands during low water or winter (frozen) conditions.
- All areas next to the watercourse that are disturbed because of the project, including temporary access roads, stockpiles, and staging areas, shall be restored to pre-project elevations.
- Except as specified in the application, no debris, silt, sand, cement, concrete, oil or petroleum, organic material, or other construction-related materials or wastes shall be allowed to enter or be stored where it may be washed by rainfall or runoff into aquatic resources.
- Disturbed areas outside stream channels that are not otherwise physically protected from erosion shall be reseeded or planted with native vegetation. Stabilization measures, including the use of vegetation, are required at the earliest practicable date, but by the end of the first full growing season following construction. Native woody riparian or wetland species, or both, shall be used in areas that support such vegetation. Plantings shall be monitored and replaced, for an overall survival rate of at least 80 percent by the end of the second growing season. Once established, native plants adapted to the site will be able to thrive with no supplemental water or treatment. Silt fences, seed-free straw mulch, biodegradable straw wattles, and other techniques shall be employed as appropriate to protect waters from sedimentation and other pollutants.

## GROUNDWATER-DEPENDENT ECOSYSTEMS: RESTORATION OF SEEPS AND SPRINGS

Springs support riparian areas can occur across the landscape, in the uplands, in the bottoms, and on the sides of cliffs. Many springs have been altered by a number of human activities that impair ecological integrity. The desired condition is often to maintain a spring's functional characteristics that are similar to their historical condition, which represents ecological integrity. These conditions may be different for each spring, and discussing this with a group of specialists will inform the most appropriate pathway to reach desired conditions.

### Manage Impacting Factors

- Livestock grazing physical effects, such as compaction and bare ground
- Wildlife and livestock herbivory
- Surface water diversion
- Water quality impacts
- Groundwater extraction
- Invasive species
- Recreation impacts

There are different types of springs, each with its own characteristics. The classification system proposed by Springer et al. (2008) is largely based on emergence setting and hydrogeology. Emergence setting is related to the sphere of discharge, the area that the water flows into from the ground, such as springs that emerge in caves and springs that flow into sinkholes or other types of vertical conduits in an aquifer. These are further described as follows:

- Cold water fountain springs are those with discharge above the land surface, forced by hydrostatic pressure. These could be called artesian springs.
- Geysers are geothermal springs that emerge explosively and usually erratically.
- Gushets are springs that merge from perched unconfined aquifers, often with dissolution along fractures. These springs usually flow as thin sheets of water flowing over rock faces.
- Hanging garden springs emerge from geologic contacts with varying flows.
- Helocrene springs emerge from indistinct or multiple sources into wetlands, wet meadows, and cienegas.
- Hillslope springs emerge from confined or unconfined on non-vertical hillslopes at 30- to 60-degree slopes, usually from indistinct or multiple sources.
- Hypocrene are springs that do not quite reach the surface. The discharge from these springs is low enough that evaporation or transpiration consumes all the discharge and there is no surface expression water.
- Limnocrene springs merge into pools of surface water, such as a pond. Usually the pools of water are there due to the flow of water from the spring.
- Mound form springs usually emerge from precipitate or peat mounds. In the case of precipitate mounds, the chemistry of the groundwater is usually responsible for the formation of the mounds by precipitating carbonate out of the water as it reaches the surface.
- Rheocrene springs are those that discharge into streams. Some streams are almost completely spring fed, while others have a component of surface water in them.

***Design Criteria***

The design criteria for springs restoration and improvement depend on the type of spring, impacting factors, and future conditions. Many methods are suitable for work around springs that are described in other sections; these are as follows:

- Aquatic organism passage—There could be a need for this type of activity when spring flows interact with a road or trail.
- Headcut and grade stabilization—There could be a need for this type of activity when spring flows are being affected by headcuts or erosion leading towards dewatering the spring.

*Methods*

- Restore sinuosity to straightened stream segments to match expected high flows
- Channel structures to elevate the base level and reduce incision processes
- Plant native plants
- Remove old infrastructure
- Redirect water flows to original and/or sustainable flow path

- Fence
- Redesign or replace spring development to allow for flows into spring-associated ecosystem

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